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ABSTRACT

Information sheets and student worksheets for thirty-six lessons designed for a first-year electrical apprentice technical training program are presented in this workbook. The information sheets provide summary information about the lesson topics and the worksheets contain problems to be solved and questions to be answered relating to each lesson. Some of the lesson topics are tools and equipment, introduction to electricity, electromotive force, combination currents, voltage drop, cable assemblies, electrical metallic tubing, cabinets and cutout boxes, fluorescent lighting, and blueprint reading. (The instructor's manual containing lesson plans, unit tests, and worksheet answers is available as CE 018 353. Other related documents are CE 018 350-360.) (JH)

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STUDENT WORKSHEETS

RELATED INSTRUCTIONAL MATERIAL

FOR

ELECTRICAL APPRENTICE
TECHNICAL TRAINING

SERIES NO. A
(First Year)

July, 1964
Revised July, 1971
Revised to meet 1978 Electrical Code

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

CE 018 354

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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FOREWORD

The apprenticeship programs offered in North Carolina are important phases of the total educational program for industry in the state. The program of education for modern apprenticeship includes two distinct phases. The first phase is "on-the-job training." The student is employed by a firm in which he performs duties specifically assigned to enhance his learning in his field of study. These experiences are planned and supervised so that the individuals will progress through the apprenticeship phase to that of the journeyman. The second phase of the program of education is termed "related instruction." In this phase the apprentice is provided the technical and theoretical foundation subjects that help him to learn the trade thoroughly and accurately. This portion is usually taught through evening school, but in some cases may be done through correspondence courses.

The North Carolina Department of Community Colleges, through the Program Development Section, has the responsibility for developing and making available the instructional materials that provide the learner with a sound educational program which is effective and appropriate to the method in which the materials are being utilized. The department has available these materials for the students, as well as support material for the instructor who teaches or who acts as counselor in conducting the related classes.

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Department of Community Colleges

PREFACE

The Program Development Section of the Department of Community Colleges has the responsibility for making available the related instructional materials required for use in occupational programs offered by the various institutions. This responsibility is accomplished by working with advisory committees and consultants representing each of the occupations in determining the needs and in developing the materials required to meet these needs.

These information sheets and worksheets have been prepared to provide specific assignments for studying related topics necessary in the training of electrical apprentices. An effort was made to develop the schedule to follow as the apprentice progresses with his training. It will also enable the apprentice to know what skills and knowledges will be required of him. The objective of this program is to aid the instructor and employer in providing experiences necessary to develop not only a competent worker in the electrical field, but also, a well-rounded citizen.

This workbook includes assignment sheets and information sheets for the electrical apprentice to use in searching out related information. The worksheets contain problems to solve, questions to answer, diagrams to draw, and blueprints to consult. The apprentice should study the references (assigned by the instructor) before he attempts to answer the questions or solve the problems.

In actual use of these lessons, instructors should feel free to modify their application of the material to conform with local needs. For example, there may be certain sections of the Code to teach because the apprentices are working with special installations. Thus, the instructor should lead a discussion on materials that applies to these situations. In other classes, the instructor may need to spend more time with the students on topics dealing with mathematics than with blueprint reading. In any event, the minimum class time for related material is 144 hours per year. It is sincerely hoped that the assignment sheets are used correctly so that apprentices can gain maximum benefits from their related studies.

ELECTRICAL APPRENTICESHIP TECHNICAL TRAINING

ACKNOWLEDGMENTS

Questions and problems for the Lesson Topics were prepared in July, 1964 by:

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YOUR FUTURE IN THE ELECTRICAL INDUSTRY

Apprenticeship Agreement

When you decided to sign an agreement to become an electrical apprentice, it was an important decision in your life. It was a good choice if you like the work. To be successful you must strive to be above average in your work and devote many hours to the study of technical information.

You have expressed a desire to learn this trade by signing the apprentice agreement to work for moderate wages on-the-job for 2,000 hours and attend classes for at least 144 hours per year for four years. You realize that in this time you cannot learn all the "hows" on the job and all the "whys" in class. However the basic technical information and the on-the-job experience will help you become a better craftsman.

Opportunities in the Electrical Industry

The future depends entirely upon you. There are many and varied opportunities in the electrical industry for you. The wages of journeymen in the electrical trades are as good or better than those employed in other trades. A majority of the electrical contractors who operate their own businesses once worked as tradesmen. There are many jobs in maintenance and repairing of electrical equipment in industrial plants, public buildings, schools, power and light companies, and other utilities. Your future in this industry is limited only by how well you apply yourself.

The electrical industry is less than one hundred years old and is expanding by leaps and bounds. The United States produces and uses about one-half of the world's supply of electricity and has only seven percent of the population. Perhaps you can see today the many opportunities that await you tomorrow.

What are you going to do? You have the opportunity by attending the apprentice classes maintained to help you to prepare for a better life. It is the sincere hope of the committee, your employer, and your instructor that you will cooperate by working at the height of your ability.

YOUR RELATED INSTRUCTION

Introduction

The lessons prepared for the electrical apprentice have been divided into four one-year courses of approximately 144 hours each. Each lesson is designed to give you fundamental related information that will help you

progress in your work. Basic electrical theory, mathematics, job information, National Electrical Code, and blueprint reading will comprise the subjects to be studied during the four years. It will be impossible for you to learn all you need to know in class, but these courses should give you a good basic foundation.

If you are to make proper progress in the electrical wiring trade, it is necessary to understand how this related instruction is organized. Also, how to get the most out of your work on each assignment. The following information explains how to make the most efficient use of this course.

Why You Are Taking This Course

Apprentice training is an educational program in which the apprentice learns a skilled trade through a combination of work experiences on the job and related technical instruction in class. On the job, the apprentice learns how to do many of the skilled operations of the craft while working with experienced journeymen.

In the electrical wiring trade, you must learn the related information as well as the job operations. This technical knowledge is easier to learn in an organized class than on the job. The related information is available only in books, manuals, and films that can best be used in schools, with the aid of an instructor. The mechanic who knows the technical phase of his craft is better prepared to plan work, understand the plans of others, and "trouble-shoot" or solve problems. A mechanic can sometimes "get by" with a small amount of technical information, but rarely does such a man become a successful foreman, supervisor, or electrical contractor. The related information you can learn through regular school attendance and careful study of the assignments in this course will prepare you for advancement in your trade.

The Course and How to Use It

The Assignment Sheets provided for each lesson are study guides to use in searching out related information. Some contain textbook references, some have problems to solve, questions to answer, key sentences to complete, diagrams to draw, and blueprints to consult. Be sure that you study the assigned references before attempting to answer the problems or fill in the blanks.

It will be necessary to study the assignments outside of class, so be sure you understand what is required. References will be assigned by the instructor. The manual is intended to be used as a flexible guide by your instructor. It is his responsibility to make your related training as interesting as possible and at the same time provide you with the best possible basis for advancement in your trade.

Orientation

The instructor will assign the information sheets and the lesson sheets to study the week before the class meets. Be sure to read the related information carefully before completing the problems in the space provided. The lesson sheets will be checked in class and returned to you. Correct the mistakes and place the sheets in your notebook for future reference.

Testing and Evaluation

Special problems and tests will be worked out during class periods. There are short tests to be given weekly, and unit tests to be given approximately every six weeks. A final examination will be given at the end of each year. Many of these questions will be of the "open book" variety in order to use formulas, tables, and the National Electrical Code. These tests will be given to see how well you are learning the related information. Also, they will determine to a large extent your grade in the course.

Tips On How To Study

In order to make the information you study of any value, it is necessary to prepare your lessons in a way that you will remember them. This requires concentration and real effort rather than just "reading," but it pays off in the long run. Many apprentices object to being required to learn by reading, as they sometimes find it difficult to get the meaning from the printed word. The ability to read accurately and rapidly is an important advantage if you want to progress in the electrical business. The electrician who wants to get ahead or even keep up with his craft must be able to get the latest technical information by reading. Most slow readers are not aware of the handicap under which they are working. Many adults are enrolling in Reading Courses to improve their accuracy and speed. It might be to your advantage to inquire about the availability of a reading evaluation.

The following method of studying technical information has proved to be very helpful:

1. Survey the entire assignment, by "skim" reading paragraph headings and key sentences. This will give you the over-all picture of the lesson.

2. Go back to the beginning of the assignment and read the first paragraph. Now, look up from your book and try to repeat to yourself, in your own words, the meaning of the paragraph. If you cannot do this, the information did not become "fixed," and you will have to go over it again until it does.

3. Repeat the above process with each paragraph in the assignment. As you study, try to apply the information to a practical job situation.

4. Then, you are ready to complete the problems on the Assignment Sheet for the lesson. You will quickly recognize the material and be able to find the answers in less time.

References

For additional help on how to read and study profitably, find the following booklets in the library or write to the publisher for a copy.

1. How to Study, American Technical Society, Drexel at 58th Street, Chicago 37, Illinois.

2. Tips on How to Study, Delmar Publishers, Inc. Albany, New York.

3. How to Study, Morgan and Deese, McGraw-Hill Book Company, New York, New York, 1957.

NAME _____ ORIENTATION

DATE _____ A-2

YOUR APPRENTICESHIP

When you discussed your apprenticeship with the Local Committee and/or your employer, you were given some important information. You remember some of it; some has slipped from your memory. Now is a good time to refresh your mind, with the aid of your instructor, through a discussion in class so that you may have a better understanding of the rules and regulations which apply to you, your training and your trade.

QUESTIONS:

1. How many years will you be an apprentice?

2. How many hours each year will you attend related training classes?

3. What percentage wage increases will you receive during your apprenticeship? How often?

4. Are these increases automatic, regardless of your performance on-the-job and in class?

5. What is the purpose of the probationary period?

6. How many on-the-job training hours are required each year?

7. Is your Apprenticeship Agreement between you and your Employer or between you and the Local Committee?

8. Are the Standards of Apprenticeship important to you? Why?

9. How does the Local Apprenticeship Committee differ from the Apprenticeship Council?

10. How many members are on the Local Apprenticeship Committee? How are they selected?

NAME_____ ORIENTATION

DATE_____ A-3

EMPLOYEF, EMPLOYER, AND CUSTOMER

RELATIONS

The apprentice has the right to expect his employer to see that he is taught the skills of the trade under the careful supervision of competent workmen and knowledgeable instructors. He should expect to receive well-rounded experience in as many phases of electrical work as possible. The employer, on the other hand, has the right to demand that the apprentice protect his property and interests. The employer should be interested in the progress of his apprentices as they should be in the progress of the company for which they work. Both the employer and the employee should strive toward the best possible relationship. The apprentice should realize that the orders or instructions of his immediate superior or his employer are based on conditions existing in the business world and are not necessarily personal.

A contracting company may be compared to a wheel in which the office represents the hub, the men in the field represent the spokes, and the customers represent the rim. No one part can get along without the other. The owner, himself, may well have started out in the industry as an apprentice or he may have never actually worked with the tools. He is, in any event, a busy man and cannot personally supervise all phases of his company and must have qualified men to do so for him. The contractor is dependent for his success to a large degree on the ability of the employees under his direction. The success of the men on the job, on the other hand, depends considerably on management. You can readily see that the greater the employee-employer relations, the greater is the chance of success for all concerned.

Every employee expects fair wages for a fair day's work and his employer expects the opposite. A fair day's work is a matter of agreement between the two. The length of the workday, fair wages, and many other matters of concern to the employee are determined by the company policy. Every man should be familiar with these policies so that he may know exactly what he can and cannot expect as an employee of the firm for which he works.

It is the customer or client who indirectly pays the wages of the employee. Under many conditions the electrician is the only direct contact between his employer and the customer, and the customer judges the electrical company by the conduct and skill of its representative. The electrician is

charged with the responsibility of protecting and improving both his own reputation and that of his employer. This can be accomplished by working efficiently, creating the least inconvenience and being honest and tactful in dealing with the customer.

The business world revolves on salesmanship. Just as you had to sell yourself to your employer in order to become an apprentice, he must sell his firm and his services to his customers. In the future, you will be called upon to sell yourself and your skills. The better the product, the easier the job of selling. What should be considered in improving you--the product? Character and personality must receive as much attention as improving one's skills. More persons are discharged from their jobs because of personal factors that for lack of ability. Honesty heads the list in obtaining a good reputation. Once a man loses his integrity, the path to future advancement or success is almost surely lost also. In selling yourself, a long list of personality traits make the job easier. Some of these include sincerity, thoughtfulness, generosity, modesty, unselfishness, and friendliness. It goes without saying that personal appearance (how the product looks to the buyer) also plays an important part in salesmanship.

Many employees believe they will be rewarded and promoted by simply working for a specified period of time. The employer however, looks for more than routine performance of work. He looks for the man who considers himself as part of the overall team, the man who understands his job in relationship to the company and who is as concerned for the success of his firm as himself.

Questions for Discussion

1. What are the responsibilities of the employee to his employer?

2. What are the responsibilities of the employer to his employee?

3. Why are customer relations important to the employee of an electrical contractor?

4. Why is personal appearance important to one working in the electrical trade?

5. How can an apprentice affect the image of the company he works for?

6. Why is a good reputation important to an electrician?

7. Why is a good reputation important to a contractor?

8. List the personality traits you like [illegible] in the men you work with.

9. What is the difference in the method of payment of office personnel and craftsmen in the field?

10. How can an apprentice help in determining the actual cost of a job?

11. List as many items as you can think of that are covered by company policy.

12. How do wages affect the company's ability to sell a job?

INFORMATION SHEET TOOLS AND EQUIPMENT LESSON NO. A-4

TYPICAL EMPLOYEE TOOL LIST

I. For the job supervisor

A. 1 - 100 ft. measuring tape
B. Personal tools, same as electrician
C. Chalk line

II. For electrician and advanced helper

A. Tool box with padlock
B. Set of socket wrenches up to 1", 3/8" or 1/2" drive
C. K.O. set 1/2" thru 1-1/4"
D. Screw driver set of 1 each: Stubby, 4", 6", 10", Phillips
E. Adjustable wrenches, 8" and 12"
F. 1 hack saw frame
G. 1 STA-KON tool
H. 1 pair long nose pliers
I. 2 pairs channel lock pliers
J. 1 pair 9" side cutting pliers
K. 1 tap wrench with 6/32", 8/32", 10/24", 10/32", and 1/4" taps
L. 1 6' folding rule
M. 1 level 18" or 24"
N. 1 plumb bob
O. 1 Wiggins tester
P. 1 pocket knife
Q. 1 Hammer, ball pein or striking, 2 lbs.
R. 1 cold chisel set - 1/4", 1/2", 5/8" cutting edge
S. 1 set Allen wrenches up to 1/2"
T. 1 wire stripper
U. 1 chain wrench
V. 1 tape, 100 ft.
W. 1 twist drill holder
X. 1 holding screw driver
Y. 1 try square
Z. 1 chalk box

III. Beginning apprentice

A. 1 pair 9" side cutters
B. 1 screw driver set of 4", 6", 10"
C. 2 pairs channel locks
D. 1 pocket knife
E. 1 wire stripper
F. 1 folding rule, 6 ft.

NOTE: It is the responsibility of the job supervisor to see that all workers on his job payroll have tools in accordance with this schedule.

NAME_____ LESSON NO. A-4

DATE_____ WORKSHEET A-4

TOOLS AND EQUIPMENT

1. What six hand tools should a beginning apprentice have?

(a)_____ (d)_____
(b)_____ (e)_____
(c)_____ (f)_____

2. An advanced apprentice should have added the following tools:

(a)_____ (f)_____
(b)_____ (g)_____
(c)_____ (h)_____
(d)_____ (i)_____
(e)_____ (j)_____

3. A journeyman electrician should have added these tools:

(a)_____ (e)_____
(b)_____ (f)_____
(c)_____ (g)_____
(d)_____ (h)_____

4. An electrician can often be judged by the type and condition of the tools he carries. True/False. _____

5. Good tools enable the electrician to perform his work more efficiently and in a more workmanlike manner. True/False. _____

6. Listed below are some of the more familiar heavy tools which the contractor generally supplies. In the blanks provided, match the letters a, b, or c of the tool classifications which may apply to each item:

a. Material handling
b. Fabrication and assembly
c. Installation

_____Scaffolds
_____Work benches
_____Trailers and carts
_____Vacuum-blower units
_____Gang boxes
_____Ladders
_____Cranes and bucket trucks
_____Cable pulling machines
_____Trucks
_____Trenchers and back-hoes
_____Walkie-talkie radios
_____Fork-lift trucks
_____Portable generators
_____Conduit and EMT benders
_____Power drills
_____Chain hoists
_____Hydraulic knock-out sets
_____Portable power hack saws
_____Concrete saws
_____Hydraulic compression tool
_____Electric rota-hammer

INFORMATION SHEET LESSON NO. A-5

CONSTRUCTION MATERIALS

1. Any item of material installed on any electrical job should:

   (a) Be electrically safe.
   (b) Have the necessary protective cover or housing.
   (c) Have the proper insulation.
   (d) Be suited for the installed environment.
   (e) Fit the space available.
   (f) Not conflict with other trades equipment.

2. Any electrical job is made up of a group of small items connected together. A big job is just a lot of small jobs.

3. These items can be grouped into the following classifications:

   (a) Conductors
   (b) Raceways
   (c) Devices and plates
   (d) Switches and over current protective devices
   (e) Switchboards and panelboards
   (f) Transformers
   (g) Lighting equipment
   (h) Electric heating
   (i) Motors and controllers
   (j) Capacitors and regulators
   (k) Power sources
   (l) High voltage equipment
   (m) Signal and communication systems

4. Sizes and ratings of equipment:

   (a) Wire - Gauge and ampacity and insulation, multi-conductor
   (b) Conduit - Inside diameter, steel, aluminum, EMT, plastic
   (c) Switches and circuit breakers - Voltage and ampacity, interrupting capacity
   (d) Devices - Voltage and ampacity
   (e) Switchboards and panelboards - Voltage, ampacity and frame size
   (f) Transformers - Voltage, ampacity, taps, insulation, ventilation
   (g) Lighting equipment - Incandescent, flourescent, high-intensity-discharge voltage, auxillary equipment, lamps, hanging
   (h) Electric heating - Voltage, wattage, control equipment, baseboard, ceiling, duct, radiant panel, furnace
   (i) Capacitors and regulators - Voltage, output, degree of sensitivity, control
   (j) Power sources - Package unit or components, drive equipment, gas, diesel, oil, batteries, separate service, voltage, ampacity required, speed of change over

(k) High voltage equipment - Voltage, ampacity, shielding, terminations, cooling, isolating, conductors, switching
(l) Signal and communications - Type, use expected, coverage needed, capacity, interlocked with other systems, expansion, electrical or electronic

5. Related items of equipment:

(a) Wire - Terminations, lugs, tape, connectors, sealants
(b) Conduit - Straps, hangers, clips, racks, boxes, wireway, cable tray, bus duct, underfloor duct, cable duct
(c) Switches and circuit breakers - Special fuses, "Tri-Pack" units, thermal and/or magnetic trips, bolted pressure switches, enclosures
(d) Devices - Standard, special applications, twist-lock, split circuit, combination units, plates
(e) Switchboards and panelboards - Surface, flush, free standing - copper/aluminum bussing, protective devices, metering, spare/space feed-in and feed-outs
(f) Transformers - liquid-filled or dry, single or three phase, taps, enclosure, ventilation, insulation rating
(g) Lighting equipment - Mounting - direct, recessed, suspended, bases, racks, fire-proofing
(h) Electric heating - Step fusing, mechanical coordination, controls
(i) Capacitors and regulators - critical load, separate service, batteries, generators, switching equipment - automatic
(j) Power sources - Foundations, racks, auxillary equipment, fuel storage
(k) High voltage equipment - Towers or underground work, ducts or direct burial, traffic flow interruptions
(l) Signal and communications - Separate raceways, installation and hookup, warranty and service

6. NEMA enclosure types:

ENCLOSURES	EXPLANATION
NEMA Type 1 - General Purpose	To prevent accidental contact with enclosed apparatus. Suitable for application indoors where not exposed to unusual service conditions.
NEMA Type 2 - Driptight	To prevent accidental contact, and in addition, to exclude falling moisture or dirt.
NEMA Type 3 - Weatherproof (Weather Resistant)	Protection against specified weather hazards. Suitable for use outdoors.
NEMA Type 3R - Raintight	Protects against entrance of water from a beating rain. Suitable for general outdoor application not requiring sleetproof.
NEMA Type 4 - Watertight	Designed to exclude water applied in form of hose stream. To protect against stream of water during cleaning operations, etc.
NEMA Type 5 - Dust Tight	Constructed so that dust will not enter the enclosed case. Being replaced in some equipment by NEMA 12 Types.
NEMA Type 6 - Submersible	Intended to permit enclosed apparatus to be operated successfully when submerged in water under specified pressure and time.
NEMA Type 7 - Hazardous Locations A, B, C or D Class I - Air Break Letter or letters following type number indicates particular groups of hazardous locations per N.E.C.	Designed to meet application requirements of National Electrical Code for Class I, Hazardous Locations (Explosive atmospheres). Circuit interruption occurs in air.
NEMA Type 9 - Hazardous Locations E, F or G Class II, Letter or letters following type number indicates particular groups of hazardous locations per N.E.C.	Designed to meet application requirements of National Electrical Code for Class II, Hazardous Locations (Combustible dusts, etc.)

SAFETY

SAFETY PRECAUTIONS

It is an accepted fact that electricity, if not handled properly, is extremely hazardous. This fact has attributed greatly to the progress that has been made in its control. Through cooperation of manufacturers of electric equipment, governmental bodies, insurance companies, and others, the National Electrical Safety Code has been developed. This Code has played an important part in accident-prevention work.

Frequently, construction electricians working with the comparatively low voltage used in house wiring do not have the same respect for it as they do for the high voltage used in delivering current to transformers. They fail to realize that the relationship between the voltage and the resistance of the material serving as ground is the determining factor and therefore danger is not determined solely by the voltage. It should be thoroughly understood that the 110 volt current used in lighting circuits is sufficient to kill under many ordinary situations in which the electricians will be working. If the material to which the worker is grounded has low resistance to the flow of electricity, the amperage will be high, resulting in severe electric shock. Electric shock ranges from mild discomfort to actual stoppage of heartbeat and breathing. Serious burns may also result.

The extent of the injury received from electric shock is controlled mainly by the amount of current, the path of the current through the body, and the duration of the shock. The physical condition of the victim may also have a bearing. This fact should never be interpreted to mean that a strong individual should take chances with electricity.

The frequency of the current and the type of current, direct or alternating, are also factors affecting the nature of shock. High frequency current tends to produce heat instead of shock. This is also the case with direct current. Shock hazards are less, but more severe burns can be expected from direct current accidents. Accident reports indicate minor electric shock has caused serious accidents. In these cases, involuntary contraction of the muscles has caused workmen to fall from ladders and scaffolds.

While accidents with electricity are frequently serious, there are fewer safety precautions to be considered than in many other industries. The following rules should be carefully observed by all workmen employed as construction electricians.

1. Assume a circuit is alive until tested and proved dead.

2. Test circuits with proper testing equipment. (110 volt test lamp placed across a 440 volt line will blow up)

3. Use safety equipment such as insulated tools, rubber mats, and rubber gloves.

4. Main switches should be locked open and a tag indicating workmen are working on some part of the circuit before work is started.

5. Before closing a circuit, check carefully to see that workmen are clear of the circuit.

6. Observe the rules of the National Electrical Safety Code.

7. If minor repair of a live circuit cannot be avoided, arrange to have a qualified helper present.

8. Make all parts of a job safe even though they are temporary.

Aside from the hazards of electric shock, the construction electrician is subject to accidents similar to those encountered by other workmen in the building trades, such as falling from ladders and scaffolds, accidents in manipulation of tools, etc.

Falling is a major cause of industrial accidents. Workmen should avoid improvised steps and ladders. Dependable ladder and scaffolding equipment is available and should be used. Ladders should be inspected frequently to see that rungs or steps are not overly worn, loose, broken, or missing. Rails that are badly split should be discarded. Antislip feet are desirable for both step and straight ladders. They should be of a type designed for the particular purpose. The design of step ladders is an important factor in stability. Frequently, improper placing of ladders results in their slipping, or the workman trying to reach too far and becoming overbalanced.

NAME _____ LESSON NO. A-6

DATE _____ WORKSHEET A-6

SAFETY

1. List some ways that safety habits are responsible for cash savings.
   a. To your company as the employer.

   b. To you as the employee.

2. List several pieces of wearing apparel classed as safety equipment generally furnished by the company.

   a. _____ c. _____

   b. _____

3. In the event you are disabled, how much would you collect per week from Workmen's Compensation? $_____

4. Recall an accident that happened to you in the home or on the job. What safety rule was broken?

5. Give five safety habits an electrician should practice.

   a. _____ d. _____

   b. _____ e. _____

   c. _____

6. Write your favorite safety slogan.

7. Name five hazards on any construction job.

   a. _____ d. _____

   b. _____ e. _____

   c. _____

8. List five "unsafe conditions" that may show up in the normal use of a ladder by an electrician.

a. _____ d. _____

b. _____ e. _____

c. _____

9. List five "unsafe acts" that may happen on ladders.

a. _____ d _____

b. _____ e. _____

c. _____

10. Show how good housekeeping is very much a part of your job. How is good housekeeping a good indication of a safe worker?

CONDUCTORS AND INSULATORS

Conductors of Electricity

Copper is used as the most common conductor of electricity. From the figures below you can see that it contains nearly as many free electrons per square inch as silver and is less expensive.

Copper contains about 1,600,000 billion billion free electrons per square inch. (In electrical mathematics, this number is written 16×10^{23} and means 1,600,000,000,000,000,000,000,000.) The following list of common conductors show that as the number of free electrons decreases, the ability to conduct electricity decreases. It is a fact that when equal voltage is applied, the better materials will conduct more electricity.

Material	Free Electrons Per Cubic Inch	Material	Free Electrons Per Cubic Inch
Silver	16.4×10^{23}	Nickel	3.5×10^{23}
Copper	16×10^{23}	German Silver	3.3×10^{23}
Aluminum	9×10^{23}	Nichrome	2.5×10^{23}
		Iron	2.2×10^{23}

Insulators of Electricity

The materials considered to be the best insulators contain very few free electrons compared with metal conductors. It should be remembered that there is no material known as a perfect electrical insulator. It is evident that some electrons will flow when the material is subjected to voltage. Thus, when only a few electrons will flow, the material can be considered to be a good insulator. The following is a list of insulating materials and the amount of free electrons they contain per cubic inch:

Hard rubber	3	Waxed mahogany	670,000
Paraffin	270	Plate glass	1,380,000
Clear mica	14		

NAME_____ LESSON NO. A-7

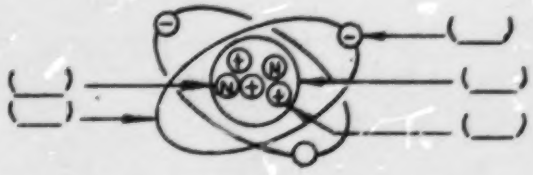
DATE_____ WORKSHEET A-7

INTRODUCTION TO ELECTRICITY

1. Matter is anything which has weight and occupies _____.

2. The smallest particle of matter is an _____.

3. The atom:



Match the number with the correct item in the above sketch.

1. Proton
2. Electron
3. Orbit
4. Nucleus
5. Neutron

4. An atom is electrically neutral because it consists of equal number of positive charges called _____ and negative charges called _____.

5. Draw an arrow to the correct answer

Electrons are	electrically positive
Protons are	electrically neutral
Neutrons are	electrically negative

6. Electrical energy can be _____ by forcing electrons to move in certain paths.

7. Like charged particles will attract each other and unlike charged particles will repel each other. True/False _____

8. All electrons are alike regardless of the atoms of which they are a part. True/False _____

9. What is an insulator? Give two examples.

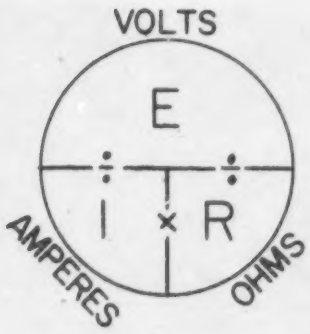
_____

_____

10. What is a conductor? Give two examples.

_____

_____



OHM'S LAW

OHM'S LAW
(MODIFIED)

NAME_____ LESSON NO. A-8

DATE_____ WORKSHEET A-8

OHM'S LAW

1. List five applications for using Ohm's Law:

   a. _____ d. _____

   b. _____ e. _____

   c. _____

2. List three situations which Ohm's Law cannot be applied.

   a. _____

   b. _____

   c. _____

3. Express Ohm's Law for finding voltage. _____

   _____

4. Expreas Ohm's Law for finding current. _____

   _____

5. Express Ohm's Law for finding resistance. _____

   _____

6. Match Column B to Column A.

(A)	(B)
1. EMF _____	1. Resistance
2. Current _____	2. Ohms
3. Opposes current flow _____	3. Electrical Pressure
4. Resistance measured in ____	4. Voltage ÷ Resistance
	5. Voltage ÷ Current

7. State the seven steps to be followed in solving problems using Ohm's Law:

a. _____

b. _____

c. _____

_____

d. _____

e. _____

_____

_____

f. _____

_____

g. _____

_____

8. Solve the following:

a. Find the voltage to operate a light if it has 60 ohms resistance and draws 2 amperes.

b. Find resistance of a load if the voltage is 110 volts and draws 2.75 amperes.

c. If a 15 ohm resistance is connected to a 60 volt generator What current would flow?

NAME_____ LESSON NO. A-9

DATE_____ WORKSHEET A-9

CURRENT

1. (a) An electric current is measured in _____.

   (b) Give symbol for current. _____.

2. True or False.

   (a) Current is the flow of electrons. _____.

   (b) The flow of an alternating current is reversed at regular intervals. _____.

   (c) A voltmeter measures current in units of amperes. _____.

   (d) The two general classes of electric currents are Direct and Alternating. _____.

   (e) An ammeter is connected across the load or (parallel) in a circuit. _____.

   (f) One ampere is equal to a flow of 6 billion, billion electrons per second. _____.

   (g) A direct current always flows in the same direction. _____.

3. The flow of electrons is called an _____ _____.

4. Draw a Simple Series Circuit using a Battery, Light, and Ammeter. Show how to wire in Ammeter.

NAME_____ LESSON NO. A-10

DATE_____ WORKSHEET A-10

RESISTANCE

1. True or False

   (a) Resistance is measured in ohms and has a symbol I. _____.

   (b) Resistance opposes the flow of electricity. _____.

   (c) An ohmmeter is used to measure resistance in a circuit. _____.

   (d) There is no need to cut power off to check a circuit with an ohmmeter. _____.

   (e) Resistance causes heat to be produced by a current through it. _____.

2. List four factors affecting resistance of a conductor.

   (a)

   (b)

   (c)

   (d)

3. Choose one.

   (a) Conductors of _____ resistivity are used for transmission lines and feeders. (a) high (b) low.

   (b) Conductors of _____ resistivity are used for incandescent lamps and toasters. (a) low (b) high.

4. What are the resistivities of the following conductors?

   (a) Copper _____
   (b) Aluminum_____
   (c) Silver _____
   (d) Tungsten_____

5. Which of the four mentioned above is the best conductor? _____.

6. The two wire gages used in this country are:

   (a)_____

   (b)_____

7. Express the following temperatures in degrees Fahrenheit:

   (a) 0° C _____

   (b) 22° C _____

   (c) 90° C _____

   (d) 100° C _____

8. Resistance (increases, decreases) with an increase in temperature. _____

9. Loose connections on conductors will (increase, decrease) the resistance. _____

10. A #10 aluminum wire (will, will not) carry the same current as a #10 copper wire. _____

11. The resistance of a copper conductor is 45 ohms at 65° F. What is the resistance at 194° F?

NAME_____ LESSON NO. A-11

DATE_____ WORKSHEET A-11

ELECTROMOTIVE FORCE

1. Can electricity be created or destroyed? Yes/No. _____.

2. List seven ways of producing an EMF.

   (a) _____
   (b) _____
   (c) _____
   (d) _____
   (e) _____
   (f) _____
   (g) _____

3. Choose one.

   (a) Electromotive force is measured in _____.
   (a) Amperes (b) Ohms (c) Volts

   (b) The _____ of voltage will cause an increase in current.
   (a) increase (b) decrease

   (c) The symbol for voltage is _____.
   (a) E (b) I (c) R

   (d) The instrument used to measure voltage is _____.
   (a) Ammeter (b) Ohmmeter (c) Voltmeter

4. How should a voltmeter be connected in the circuit? _____
   _____.

5. Define voltage drop. _____
   _____

6. What causes electrons to move once a switch is closed in an electrical circuit? _____.

7. Define potential difference. _____
   _____.

NAME_____ LESSON NO. A-12

DATE_____ WORKSHEET A-12

POWER AND WORK

1. The capacity of doing work is _____.

2. The time rate of doing work is _____.

3. Mechanical power depends upon work and speed. The unit of measurement of mechanical power is _____.

4. Electrical power is the product of current and voltage. The unit of measurement of electrical power is the _____.

5. A horsepower is a unit of mechanical power. It is equal to _____ foot pounds per minute.

6. The electrical work done in one hour by one watt is a _____.

7. A kilowatt equals _____ watts.

8. One _____ of electrical power is used when one volt causes one ampere of current to flow in a circuit.

9. One horsepower equals _____ watts (750 for calculations).

10. The energy or power supplied to the machine is called _____.

11. The useful energy or power delivered by the machine is called _____.

12. Efficiency is the ratio of output to input. Efficiency = _____.

13. Efficiency is always less than 100%. Why?_____

_____

14. If a lamp draws 2.5 amperes at 120 volts, how much power is consumed?

a. 120 watts b. .0208 watts c. 300 watts _____

15. An electric heater is rated at 900 watts and operates on 120 volts. How much current does it use?

a. 7.5 amps b. 10.8 amps c. .13 amps _____

16. An electric toaster uses 1200 watts and is rated at 10 amperes. The correct voltage for this appliance would be:

    a. 110 volts b. 115 volts c. 120 volts _____

17. Can six 200 watt lamps be connected in series on a 120 volt line? _____.

18. A motor draws 3 amperes as it operates at 250 volts. How much power is consumed? _____. What is the horsepower rating of this motor? _____.

19. How many kilowatts could a 400 horsepower generator produce? _____.

NAME_____ LESSON NO. A-13

DATE_____ WORKSHEET A-13

SERIES CIRCUITS

1. True or False

   a. In a series circuit, current remains the same throughout the circuit. _____.

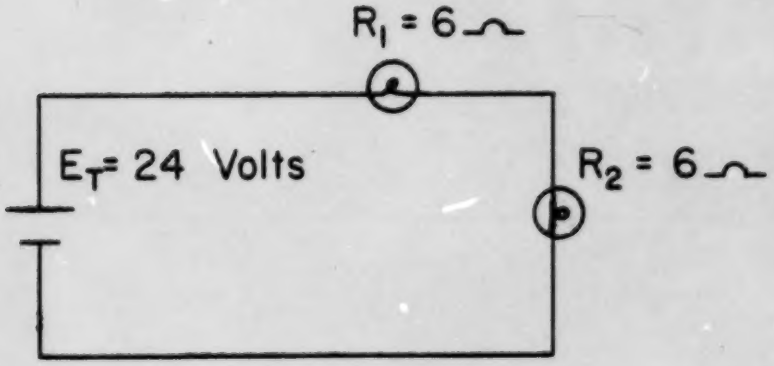
   b. In a series set of Christmas lights, if one lamp burns out, the other lamp will continue to burn. _____.

   c. Ohm's Law may be used to find the unknown values of all parts of a series circuit. _____.

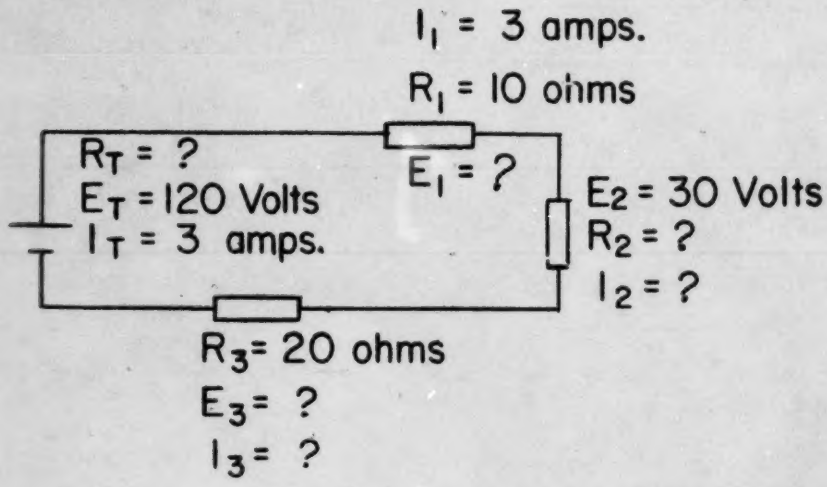
   d. In a series circuit there is more than one path for current to flow. _____.

   e. The total resistance is equal to the sum of all the resistors connected in the circuit when they are connected series. _____.

2. Solve for current:



3. Solve for each unknown:



R_t = _____

E_1 = _____

I_2 = _____

R_2 = _____

E_3 = _____

I_3 = _____

4. Describe the following symbols:

a. E_t _____

b. I_1 _____

c. R_4 _____

d. I_T _____

e. E_1 _____

f. E_4 _____

g. R_T _____

5. A current of 3 amperes is flowing through a series circuit having four resistors with voltage drops across each respectively 12 volts, 15 volts, 30 volts, and 45 volts. Find total resistance and total voltage.

6. A bell is designed to operate at 0.20 amps and 2.4 volts. Find the resistance to be connected in series with the buzzer in order to operate the buzzer on an eight volt source.

NAME _____ LESSON NO. A-14

DATE _____ WORKSHEET A-14

PARALLEL CIRCUITS

1. True or False

   a. The current divides in a parallel circuit. _____.

   b. In a parallel circuit the voltage drop is the same across each branch and is equal to the total voltage. _____.

   c. In a parallel circuit the total current is equal to the sum of the currents in each branch. _____.

   d. Parallel circuits are also identified as branch circuits. _____.

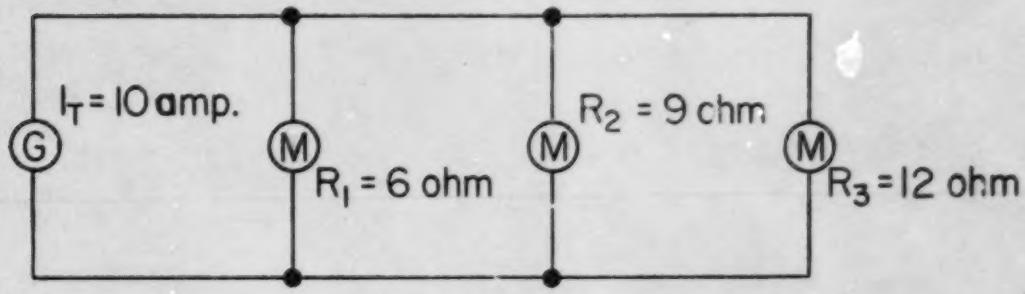
   e. The total resistance is always smaller than the smallest resistor connected parallel in a parallel circuit. _____.

2. Draw a circuit consisting of three lights connected parallel. Identify hot wire and neutral wire.

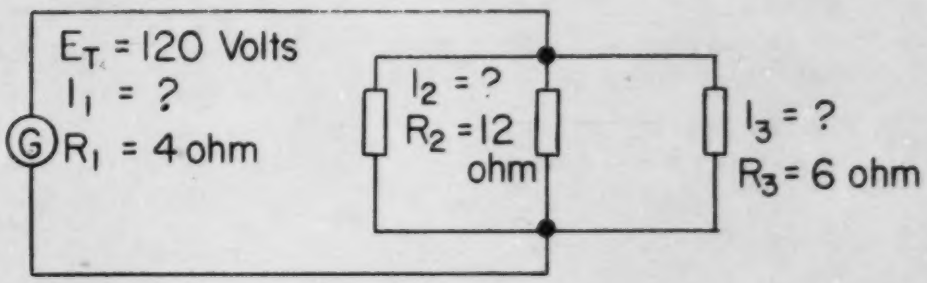
3. Write the two formulas for finding total resistance in parallel.

4. Find the total resistance of a 20 ohm resistor and a 30 ohm resistor connected in parallel.

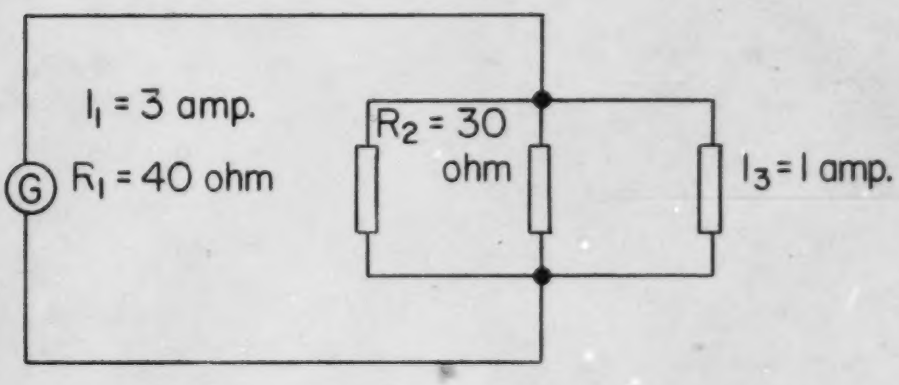
5. Find the current to each resistor of the following circuit.



6. Find the total current and current in each branch of the following circuit.



7. Find the total voltage, total current and total resistance of the following circuit.



NAME _____ LESSON NO. A-15

DATE _____ WORKSHEET A-15

COMBINATION CIRCUITS

1. List two disadvantages of series circuits.

   a. _____

   _____

   _____

   b. _____

   _____

   _____

2. List two advantages of parallel circuits.

   a. _____

   _____

   _____

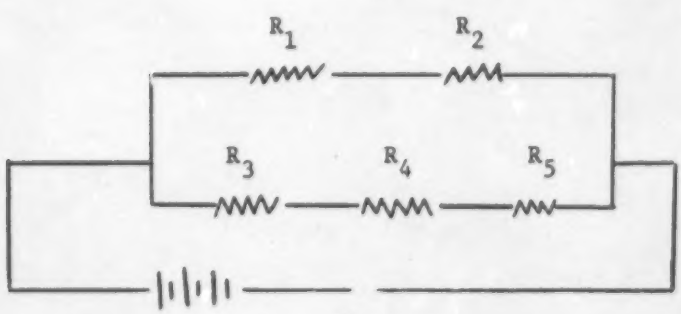
   b. _____

   _____

   _____

3. True or False

   a. The circuit below is a series parallel circuit. _____.



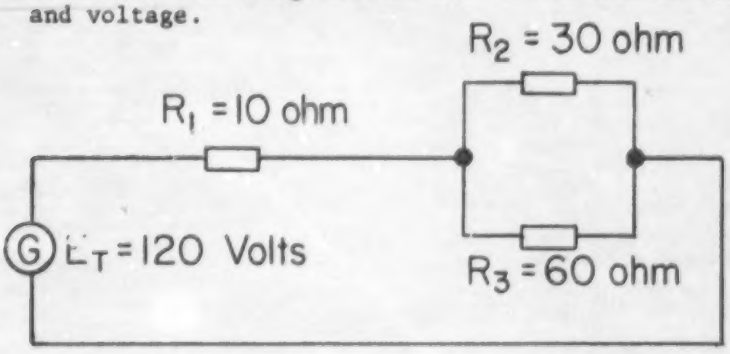
4. Find the total resistance of the circuit in question three if R_1 = 6 ohms, R_2 = 24 ohms, R_3 = 3 ohms, R_4 = 9 ohms, and R_5 = 18 ohms.

5. List two functions a series circuit performs.

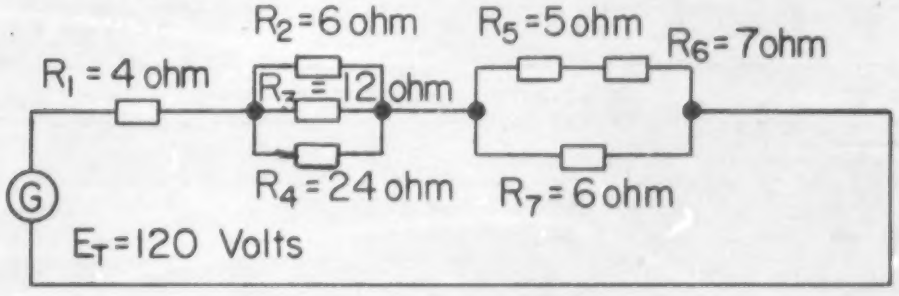
   a. _____

   b. _____

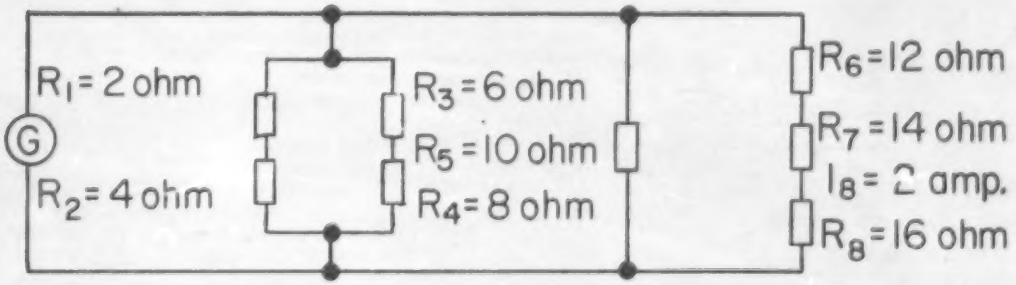
6. Solve the following circuit for all values of current, resistance, and voltage.



7. Solve the following circuit for all values of current, resistance, and voltage.



8. Solve the following circuit for all values of current, resistance, and voltage.



NAME _____ LESSON NO. A-16

DATE _____ WORKSHEET A-16

WIRE CONSTRUCTION

1. A wire is a slender _____ or _____ of drawn _____.

2. A conductor is a wire or combination of wires not _____ from each other and suitable for carrying a _____ electric current.

3. One wire of any stranded conductor is called a _____.

4. Stranded conductors are more flexible than solid conductors. True/False _____.

5. A cable may be a _____ conductor or a _____ of two or more conductors laid together but _____ from one another.

6. A small, flexible, insulated cable is called a _____.

7. Wire sizes in this country are expressed in _____. This is the cross sectional area of the conductor.

8. A wire _____ is used to determine the size of a wire or cable.

9. The larger the gage number, the _____ the size of the wire.

10. In this country we use the _____ (AWG) as the standard measure of electrical wires.

11. List the six (6) most common metals used in the construction of wires and cables:

(a) _____ (d) _____
(b) _____ (e) _____
(c) _____ (f) _____

12. Copper is the most commonly used material for wires and cables due to its _____ resistance.

13. The three grades of hardness of copper wires are: (a) _____ (b) _____ (c) _____.

14. If aluminum wires are used, a _____ size wire may have to be used to carry the current necessary to serve the load.

15. One mil equals _____ inches.

16. A circular mil is a unit of area equal to the area of a circle having a diameter of one _____.

17. The area of a circle, in circular mils, is equal to the square of its diameter, in mils. True/False _____.

18. One square inch equals $\frac{4}{\pi}$ x 1,000,000 circular mils, or 1,273,200 circular mils. True/False _____.

19. The larger wire sizes are usually expressed in "thousands of circular mils." Abbreviated ____ ____ ____.

20. The conductivity of copper used in electrical work is based on annealed copper wire. True/False _____.

21. A good conductor has high/low _____ resistance.

22. The longer the conductor, the greater/less _____ the resistance.

23. Increasing the wire size raises/lowers _____ the resistance if the same load is applied.

24. Increasing the temperature will increase/decrease _____ the resistance of a conductor.

25. Four factors which affect resistance are:

(a) _____

(b) _____

(c) _____

(d) _____

NAME _____ LESSON NO. A-17

DATE _____ WORKSHEET A-17

WIRE INSULATION

1. The six major classifications of wire and cables are:

   (a) _____
   (b) _____
   (c) _____
   (d) _____
   (e) _____
   (f) _____

2. Covered conductors are protected against mechanical injury only. Two examples of covered conductors are:

   (a) _____ (b) _____

3. An insulated conductor is one covered with material _____ as insulation.

4. What conductor has no covering or insulation? _____

5. Conductors for electrical installations are generally made of _____ or _____.

6. Conductors # _____ and larger installed in raceways shall be stranded. Conductors # _____ and smaller may be solid or stranded.

7. Insulated conductors can either be single conductors or multi-conductor cables. True/False _____

8. Three advantages of single conductor cables:

   (a) _____
   (b) _____
   (c) _____

9. Three advantages of multiple conductor cables:

   (a) _____
   (b) _____
   (c) _____

10. What is used in multiple conductor cables to fill up the spaces between the conductors? _____.

11. List the seven characteristics for an ideal insulating material:

(a) _____
(b) _____
(c) _____
(d) _____
(e) _____
(f) _____
(g) _____

12. Maximum voltage for insulated conductors in the National Electrical Code is _____ volts unless otherwise specified.

13. Rubber insulations listed in the National Electrical Code include those made from _____ and _____ rubber, _____ and other vulcanizable materials.

14. Thermoplastic insulations are also listed in the National Electrical Code. True/False _____.

15. Match the following letters with the correct National Electrical Code wire trade names:

XHHW	_____	1. Asbestos covered, heat resistant
V	_____	2. Thermoplastic
THW	_____	3. Heat resistant rubber
MI	_____	4. Heat resistant thermoplastic
THHN	_____	5. Mineral insulation
AF	_____	6. Heat and moisture resistant cross-linked thermosetting polyethylene
FEP	_____	7. Varnished cambric
RH	_____	8. Fluorinated ethylene propylene
T	_____	9. Moisture and heat resistant thermoplastic
RHW	_____	10. Moisture and heat resistant rubber

16. What insulation provides the highest electrical breakdown strength, greatest reliability, and longest life of any insulating material? _____.

17. The protective covering applied to some conductors offers additional insulation value. True/False _____.

18. Check the five factors used to determine the type insulation a conductor must have.

(a) Wet locations (c) Specific locations (e) Temperature
(b) Dry locations (d) Special applications (f) Altitude

19. Conductors with different insulation types can be used to make up a multi-wire circuit. True/False _____.

NAME_____ LESSON NO. A-18

DATE_____ WORKSHEET A-18

VOLTAGE DROP

1. Voltage drop in an electrical circuit:

   (a) Can be limited
   (b) Can be eliminated
   (c) Is of little importance
   (d) Has no connection with power loss

2. The National Electrical Code permits a feeder voltage drop of not more than _____% for power, heating or lighting loads and the maximum total voltage drop for feeders and branch circuits should not exceed _____%.

3. The feeder voltage drop is measured from the service entrance to the branch panelboard. True/False _____.

4. A branch circuit voltage drop would be from the branch panelboard to the center of the branch circuit load. True/False _____.

5. Voltage drop at a load is equal to the supply voltage minus the _____.

6. Voltage drop calculations are usually not necessary for residential and small commercial work unless the branch circuit run exceeds _____ feet to the center of the load.

7. Under most circumstances the resistance of an AC circuit is equal to a DC circuit when calculating voltage drop. True/False_____.

8. Which of the following items are not needed in calculating voltage drop?

   (a) Circular-mil area of wire (D)
   (b) Distance to the load (one way) expressed in feet (L)
   (c) Current in amperes (load) (I)
   (d) Voltage drop allowed (V)
   (e) Resistance per OHM foot for the conductor (R)
   (f) An electrolyte (E)
   (g) Resistivity of conductor cir mil-Ohms/ft. (K) use "12"

9. The following are formulas for two wire single phase circuits:

   (a) $V = \frac{2KxLxI}{D^2}$
   (b) $L = \frac{VxD}{2KxI}$
   (c) $I = \frac{VxD}{2KxL}$
   (d) $D^2 = \frac{2KxLxI}{V}$

10. The voltage drop in a 3 phase 4 wire circuit when the loads are nearly balanced is the same as a two-wire single phase circuit. True/False _____.

11. Listed below are standard circuit distances allowed:

Wire Size	Distance	
	120V	277V
#12	0' - 50'	0' - 110'
#10	51' - 80'	111' - 180'
# 8	81' - 140'	181' - 250'

12. The voltage drop in a 3 phase 3 wire circuit is the same as a 2 wire single phase circuit multiplied by 0.866. True/False _____.

13. What size copper wire is required in a 120 volt circuit to transmit 20 amperes a distance of 130 feet, with a voltage drop of 3 percent?

(a) # 10 (c) # 8

(b) # 12 (d) # 14

14. What is the maximum current in a 120 volt circuit in which two #10 copper wires transmit this current a distance of 100 feet with a voltage drop of 2 percent?

(a) 30.2 amps (c) 13.3 amps

(b) 11.5 amps (d) 26.4 amps

15. A load is connected to one of the phase wires and to the neutral wire of a 4 wire 3 phase system. What formula should be used for determining the voltage drop in this circuit?

16. A group of fluorescent fixtures is located 400 feet from the source, which is 120 volts. If these fixtures draw 18 amperes and a voltage drop of 2 percent is desired, what size wire should be used?

(a) # 8 (c) # 2

(b) # 7 (d) # 5

NAME _____ LESSON NO. A-19

DATE _____ WORKSHEET A-19

INTRODUCTION TO NATIONAL ELECTRICAL CODE

1. The purpose of the code is the practical safeguarding of persons, and of buildings and contents from dangers arising from use of electricity. True/False. _____

2. The code covers installations by electric utilities. True/False. _____

3. The code is not intended as an instruction manual for; _____

   (a) qualified electricians (c) contractors

   (b) inspectors (d) untrained persons

4. The code is revised periodically: _____

   (a) 5 yrs. (b) 2 yrs. (c) 3 yrs. (d) 1 yr.

5. The code covers electrical conductors and equipment installed within public and private buildings. True/False. _____

6. Equipment that can be removed or adjusted without disturbing the building structure or finish is called: _____

   (a) accessible (c) enclosed

   (b) permanent (d) weatherproof

7. A _____ _____ is utilization equipment at a specific location installed to perform one or more functions.

8. _____equipment is acceptable to the authority enforcing the code.

9. A conductor having no covering or insulation is a _____ conductor.

10. What is a disconnecting means?

11. _____ equipment is surrounded by a case which will prevent a person from accidentally contacting live parts.

12. Exposed wiring is concealed. True/False. _____

13. A ground fault is a conducting connection between an electrical circuit and the earth. True/False. _____

14. A grounded conductor is intentionally connected to the earth and is also called "_____ _____" or "_____."

15. An equipment ground conductor is called: _____

    (a) neutral conductor
    (b) identified conductor
    (c) grounding conductor
    (d) white color conductor

16. Raceways are designed for carrying cables, wires, or busways. True/False. _____

17. What is a remote controlled circuit?

18. Draw a line to match the following:

(a) Service Cable	Overhead service conductor between the last pole and first point of attachment to the building.
(b) Service Drop	Service conductors made up in the form of a cable.
(c) Service Entrance	Conductors between the terminals of the service equipment and tap to overhead service drop.

19. Service equipment is not located near the point of entrance of supply conductors to a building, but is always located in the northeast corner. True/False. _____

20. Service equipment is intended to constitute the main control and means of cutoff for power supply to the building. True/False. _____

21. A general use switch is capable of interrupting its rated current at rated voltage and is rated in: _____

(a) horsepower (c) watts

(b) amperes (d) ohms

22. A motor circuit switch is rated in: _____

(a) horsepower (c) amperes

(b) watts (d) miles per hour

23. What is the difference between watertight and weatherproof equipment?

24. The word "shall" in the code means. mandatory or recommended

25. Working spaces adjacent to exposed live parts may be used for storage if it's a dry location. True/False. _____

26. All wiring shall be installed free from _____ - _____ and _____.

27. Equipment mounted a minimum of _____ feet above the floor usually affords good protection.in guarding of live parts.

28. Electrical equipment should be installed in a neat and workmanlike manner. True/False. _____

NAME_____ LESSON NO. A-20

DATE_____ WORKSHEET A-20

GENERAL REQUIREMENTS FOR WIRING INSTALLATION

1. What is the minimum size conductor for interior wiring work? ____

   (a) 18 (b) 14 (c) 12 (d) 10

2. What is the maximum size for solid conductors in conduit? _____

   (a) 10 (b) 6 (c) 8 (d) 500 MCM

3. List two advantages of No. 12 AWG conductors over minimum size conductor:

   (a)

   (b)

4. What advantage does a stranded conductor have? _____

   (a) Ease in handling (c) cheaper

   (b) red in color (d) hard to bend

5. All ungrounded and grounded conductors shall be protected by fuses or circuit breakers. True/False. _____

6. What position shall enclosures for overcurrent devices be mounted? _____

   (a) vertical (c) Anniegoggling

   (b) horizontal (d) Caddiwampus

7. Fuses shall not be mounted in rosettes. True/False. _____

8. Fuses and circuit breakers shall be located or _____ to prevent _____ or _____ by their operation to persons.

9. Minimum size flexible cord shall be: _____

   (a) 20 (b) 250 MCM (c) 18 (d) 16 (e) 27

10. Conductors shall not be spliced or taped within the raceway or conduit. True/False. _____

11. Minimum size conductor permitted to be connected in parallel is: ____

(a) 14 (b) 3/0 (c) 1/0 (d) 18

12. If parallel conductors are run in separate conduits, one wire of _____ _____ shall be installed in each conduit.

13. Grouping of conductors by phases in parallel runs in separate conduits will cause overheating to parts of metal by: _____

(a) Voltage (c) Power

(b) Induction (d) Ohms

14. How many inches of free conductor should each outlet have: _____

(a) 5 inches (c) 2 inches

(b) 3 inches (d) 6 inches

15. Underground conductors, No. 4 AWG or larger, entering a cabinet shall be protected by an _____ _____.

16. Article 300-3-A covers: _____

(a) Maximum Amperes (c) Conductor Insulation

(b) Maximum Watts (d) Raceway Size

17. The test for insulation resistance is made with a: _____

(a) Megger (c) Ammeter

(b) Voltmeter (d) Ohmmeter

18. In general, all interior wiring systems shall have grounded conductor that must be continuously _____ throughout the system.

19. Article 200-10 covers: three of the below list. Which one does it not cover?

(a) Lights (c) Screw shell connections

(b) Plugs (d) Swimming pools

20. All conduits must be continuous from outlet to outlet. True/False. _____

21. Match the following letter that corresponds with the numbers:

_____ 1. Article 300-11	a.	Fixture weight support.
_____ 2. Article 370-13	b.	Fixture support more than 50 pounds
_____ 3. Article 410-15	c.	Securing boxes and fittings
_____ 4. Article 410-16	d.	Securing conduit

22. The maximum No. 12 AWG conductors permitted in an outlet box 2-1/8 x 4-11/16 square shall be:

(a) 20 (b) 25 (c) 15 (d) 10 (e) 18

23. All junction boxes shall be installed with the wiring _____.

24. Boxes installed in wood walls shall be set flush; and in tile walls the box shall be set back _____inches.

25. Gutters shall be supported at intervals not exceeding: _____

(a) 6 feet (b) 5 feet (c) 10 feet (d) 4 feet

26. Electric furnace circuits are not required to be grounded. True/False. _____.

27. Match the following wire colors by matching the letter that corresponds with the number:

_____ 1. Identified ground or neutral	a.	White
_____ 2. Equipment ground	b.	Green
_____ 3. Hot or ungrounded wire	c.	Red, black, etc.

28. There shall be a ground at each building service on the supply side of each service switch and a minimum size of No. _____.

(a) 8 (b) 6 (c) 14 (d) 20

29. How many grounding conductors shall be connected to the grounding electrode by a single fitting? _____

(a) 3 (b) 1 (c) 5 (d) None

30. No switch shall be installed in a grounded conductor. True/False.
_____

31. Match the following letter that corresponds with the number:

_____ 1.	Article 300-18	a. Sealing raceways
_____ 2.	Article 300-19	b. Splices and taps
_____ 3.	Article 374- 8	c. Vertical conductor support table
_____ 4.	Article 300- 7	d. Conductors installed in raceways

NAME _____

DATE _____

LESSON NO. A-21
WORKSHEET A-21

SINGLE CONDUCTOR WIRING

1. Single conductor wiring can be either exposed or concealed. True/False _____.

2. Single conductor wiring can be used for both branch circuit and feeder wiring. True/False _____.

3. Can a bare conductor be used for single conductor wiring? Yes/No _____. Give the Code Section for your answer. _____.

4. Single conductor wiring is restricted to residential wiring only. True/False _____.

5. The conductor separation for open wiring for voltage not exceeding 300 volts is _____ inches, and for voltage not exceeding 600 volts is _____ inches.

6. Tie wires for open or concealed wiring do not have to be insulated. True/False _____.

7. Open wiring passing thru floors and walls can be bunched together in a single sleeve. True/False _____.

8. Conductor separation for concealed knob and tube work is the same as open wiring. True/False _____.

9. Splices and taps in open and concealed wiring can be made only in outlet boxes. True/False _____.

10. The maximum length of flexible non-metallic tubing allowed is _____ feet. It must be secured with straps spaced not more than _____ feet apart.

11. Single conductor wiring may be attached to non-metallic water piping on the bottom side. True/False _____. Give the N. E. Code Section for your answer. _____.

12. Open or concealed knob-and-tube wiring current ampacity is the same as conductors installed in metal conduit. True/False _____. Give the N. E. Code Section for your answer. _____

13. Open conductor feeders are the least expensive way to install large size feeders in industrial jobs. True/False _____. Explain your answer. _____
_____

14. Single conductor wiring cannot be electrically connected with a metallic raceway system. True/False _____.

NAME_____ LESSON NO. A-22

DATE_____ WORKSHEET A-22

CABLE ASSEMBLIES

1. The code designations on non-metallic sheathed cable are:

   (a) _____
   (b) _____

2. The basic difference in the two cables listed above is _____
   _____

3. Conductor sizes for non-metallic sheathed cable range from #_____ thru #_____ for copper conductors and #_____ thru #_____ for aluminum conductors.

4. The uninsulated or bare conductor is for _____ purposes only.

5. There may be two or more insulated conductors in a non-metallic sheathed cable. True/False _____.

6. The insulation of the individual conductors shall comply with the requirements for the type of conductors used. True/False_____.

7. The code designations of service-entrance cable are (a) _____, (b) _____.

8. The basic difference in the two cables listed above is _____
   _____.

9. Which of these cables is required to have inherent protection against mechanical abuse? _____.

10. The identified conductor in a service entrance cable may be smaller than the ungrounded conductors. True/False _____.

11. Can the uninsulated conductor of service entrance cable used as a branch circuit be used as the neutral. Yes/No _____.

12. Can single conductors having approved insulation be installed as underground service entrance conductors? Yes/No _____.

13. Underground feeder and branch circuit cable has the code designation of type _____.

14. Sizes for these cables range from #_____ AWG to #_____AWG inclusive.

15. What is the minimum depth for cables buried directly in the earth? _____. Can this depth be reduced? Yes/No _____.

16. If the second answer in question #15 above is yes, explain what requirements must be met.

_____

_____

17. Under what conditions can underground feeder and branch circuit cable be installed in cable tray?

_____

18. All underground feeder and branch circuit cable is approved for exposure to direct rays of the sun. True/False _____.

19. The current carrying capacity of the conductors covered in this assignment are those listed in Tables 310-16 and 310-18. True/False _____.

20. Type _____ cable is a factory assembly of two or more insulated conductors in an extruded core of moisture-resistant, flame-resistant, non-metallic material, covered with an overlapping spiral metal tape and wire shield, and jacketed with an approved non-metallic material.

21. The above cable has two special uses--list them.

(a) _____
(b) _____

22. Type _____ cable is an assembly of parallel conductors formed integrally with an insulating material web.

23. The above cable is used for branch circuit wiring to supply:

(a) _____ (c) _____
(b) _____

24. The cable may have three or _____ conductors of special # ____ AWG copper wire protected by a branch circuit of not more than _____ amperes.

NAME_____ LA JON NO. A-23

DATE_____ WORKSHEET A-23

METALLIC SHEATHED CABLES

1. Listed below are the code type designations and descriptions. Draw a line to connect the correct type with its description.

ALS	Armored cable
MI	Armored cables with lead covered conductors
ACT	Metal clad cable
MC	Mineral insulated cable
ACL	Armor clad cable with thermoplastic conductors
AC	Aluminum sheathed cable

2. The three basic metallic sheathing metals used in the protective covering are:

   (a) _____

   (b) _____

   (c) _____

3. This metallic sheathing can be used as an equipment grounding conductor. True/False _____.

4. This metallic sheathing can be used as a current carrying conductor (a "neutral" could be a current carrying conductor). True/False _____.

5. The conductor insulation must be suitable for the use and location. True/False _____.

6. The mineral insulation used in type MI cable is _____.

7. The individual conductors of multi-conductor type MI cable have no individual insulation. True/False _____.

8. The cable termination fittings for all types of metallic sheathed cables are identical. True/False _____.

9. Which two of the metallic sheathed cables require a special approved insulating bushing?

   (a) _____ (b) _____

10. Which one of the metallic sheathed cables is approved for Class I, II, and III hazardous locations? _____.

11. Which two types of metallic sheathed cables are approved for installation underground without supplemental corrosion protection?

    (a) _____ (b) _____

12. All types of metallic sheathed cables are approved for dry locations. True/False _____.

13. What are the four major insulating materials used for conductor insulation?

    (a) _____

    (b) _____

    (c) _____

    (d) _____

14. The three basic types of sheathing used on metallic sheathed cable are:

    (a) _____

    (b) _____

    (c) _____

15. The support methods for metallic sheathed cables are the same as other cable assemblies. True/False _____.

16. The trade name for type AC cables is _____.

17. Can the outer sheath of MC type cable be used for equipment grounding purposes? Yes/No.

NAME_____ LESSON NO. A-24

DATE_____ WORKSHEET A-24

SPECIAL CORDS AND WIRES

1. Flexible cords and cable types are described where in the Code Book? _____.

2. List the eight (8) approved uses for flexible cord.

   (a) _____.
   (b) _____.
   (c) _____.
   (d) _____.
   (e) _____.
   (f) _____.
   (g) _____.
   (h) _____.

3. When flexible cord is used to serve an appliance or lamp the cord will be equipped with an attachment plug. True/False. _____.

4. List five (5) uses of flexible cords prohibited by the Code.

   (a) _____.
   (b) _____.
   (c) _____.
   (d) _____.
   (e) _____.

5. Splices and taps can be made in flexible cord. True/False. _____.

6. Tying a knot in the conductors of a flexible cord to keep strain off the terminal screws is prohibited by the Code. True/False. _____.

7. A flexible cord containing more than three (3) current-carrying conductors has to be de-rated. True/False. _____.

8. What are the five major insulating materials used in flexible cords?

   (a) _____ (d) _____
   (b) _____ (e) _____
   (c) _____

9. All flexible cords have an outer covering. True/False. _____.

10. All flexible cords have a grounding conductor. True/False. _____.

11. In a five conductor flexible cord there could be five different colored conductors as listed below. Give the intended use of each colored conductor.

    (a) Black _____ _____

    (b) Red _____

    (c) Blue _____

    (d) White _____

    (e) Green _____

12. What are the four approved insulations for fixture wires?

    (a) _____ _____ (c) _____
    (b) _____ (d) _____

13. Which of the above insulation types offers the highest ampacity rating? _____

14. What section of the Code permits the use of a #16 or #14 AWG fixture wire being protected by a 20 ampere overcurrent protective device? _____

15. Fixture wires can be used as branch circuit conductors. True/False. _____.

INFORMATION SHEET LESSON NO. A-25

RIGID METAL CONDUIT BENDING

The art of conduit bending with hydraulic equipment, although still dependent upon the skills of the individual, has been simplified by workable formulas that are easily learned and applied. The principle upon which these formulas are based is safety. The NEC states that bends must be so made that the conduit is not injured and its internal diameter is not effectively reduced. It further states in a table the minimum inside radius of conduit bends.

RADIUS OF BEND

Various factors influence, and in some circumstances determine the radius of a bend. Generally, it should be the longest radius possible. Although the inside radius of a field bend is specified in the National Electrical Code in terms of minimum radius, the specification is intended to insure an undamaged elbow and safe passage for cable. When it comes to actually installing cable in conduit, the relative ease or difficulty of the pull becomes very important to the electrician. Experience quickly teaches you that it is easier to pull cable through a long sweeping elbow than it is through a short, more tightly bent one. Of course, the radius of the bend is the determinant here, for as the radius length increases, the sweep or arc of the bend increases.

From the experience of many electricians, the "rule of thumb" has evolved that a satisfactory elbow can be made in conduit. (1) For LEAD SHEATHED CONDUCTORS by using a radius that is 10 to 12 times the internal diameter of the conduit. (2) Elbows that do not have lead sheaths require a radius equal to 8 to 10 times the conduit's internal diameter.

PRINCIPLES OF PRECISION BENDING

In "one-shot" or "segment bending" of conduit, you must be familiar with the hydraulic benders and how they operate.

Before you can make a precision bend in conduit, you must:

1. Determine the size of conduit to be bent.
2. Determine the radius of the bend.
3. Determine total degrees in the bend.
4. Calculate the developed length.
5. Calculate the gain.
6. Locate the center of bend.
7. Determine the number of bends required.
8. Calculate and mark spacing for bends on the conduit.

All formulas and factor tables are based on measurements to the center-line of conduit.

CONCENTRIC BENDING

Concentric bends are calculated by the same formulas and made by the same processes as those used for 90° bends. Radii and segment bending spaces will differ as each bend recurs in the next-lying run of conduit.

NOTE: Students should observe concentric bending of exposed conduit in several industrial installations.

Whether these bends are to be made in the same or varying sizes of conduit, the radius of the second of two successive concentric bends is equal to the radius of the first plus one-half the sum of their outside diameters plus the width of the spacing between them. Since concentric bends have not only a common center, but also equal separation, sufficient space must be provided between all concentric bends. This will accommodate couplings and straps sized for the largest conduit in the run regardless of their diameters.

GENERAL PURPOSE BENDING

In actual practice, the electrician finds that all hydraulic bending operations do not require an equal degree of precision. While the same mathematical principles are involved, generally, on some jobs it may not be necessary to work with centerline measurements, or to consider the gain or center location of a proposed bend.

However, minimum radius length, which in effect constitutes a safety factor in any conduit installation, and the determination of a bend's developed length cannot be overlooked.

Preliminary Calculations. The electrician's rule, states that ten times the diameter of the conduit as a satisfactory bending radius for the average bending job. The next consideration is to find out the point on the conduit the bend should start. To do this, measure the required rise from the bottom of the conduit, and from this measurement, deduct the length of the radius. The distance remaining is the starting point of the bend, measured from the end of the conduit. Now, with chalk, mark this remaining distance on the conduit as the starting point for the bend. (Illustrate on chalkboard using a 30" radius and 50" rise.)

Now, to calculate the developed length of the bend as before, multiply the radius (30") of the bend by 1.57. Mark this distance on the conduit, measuring from the start of the elbow. Bending gain is calculated by the formula--radius of bend multiplied by gain factor (from table). The overall length equals the leg length plus the developed bend length plus the riser. It is important to find the center or bend and mark it on the conduit for reference.

BENDING THE ANGLE

Experience becomes the best teacher regardless of the procedure used for bending conduit. Although, the conduit may be divided into two-inch segments and operating instructions are provided for the hydraulic equipment, the special bending accessories may differ from bender to bender. Experience has shown that it is advantageous to reserve two bending spaces, the first and the last, until the other segments are completed and the bend has been checked in place.

It should be noted that to confine the intended bending effect within a given segment, the center of the ram and shoe of the bender should be in line with the center of each bending space (segment). This will provide better overall control and accuracy.

NAME _____ LESSON B-20

DATE _____ WORKSHEET

MOTOR CIRCUITS

1. Explain what the N. E. Code means when it specifies that some equipment shall be "in sight from" another equipment.

_____

_____

2. List the information that should be on the name plate of a motor.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

3. What are the three types of motor circuit conductors? Give the N.E. Code Section for each type.

	Types	Code Section
a.	_____	_____
b.	_____	_____
c.	_____	_____

4. Draw a one line Schematic Diagram showing three motors connected. Show all disconnects, feeders, branch circuits, and overcurrent protection. Give the N. E. Code Section for each provision. Show or list the Branch Circuits located less than 25 feet from main.
(Space for answer on next page.)

11. The maximum number of bends permitted in one conduit run is four quarter bends or total 360 degrees. True/False. _____

12. Standard length of rigid conduit shall be 5 feet. True/False. _____

13. There are two types of rigid-steel conduit white-galvanized and black enameled. List four of their advantages:

a. _____

b. _____

c. _____

d. _____

14. Each conduit run shall terminate in an _____ outlet box.

15. Tops of a junction shall never be _____.

16. What is the method for fastening conduit to the junction box?

_____

_____

17. What is a popular field bender?

(a) railroad track
(b) between two iron beams
(c) hickey
(d) hydraulic jack

18. Care must be taken in feeding conductors in conduit to prevent _____ or _____.

19. Name uses permitted with intermediate metal conduit.

(a) _____
(b) _____
(c) _____

20. What are the minimum and maximum trade signs of intermediate metal conduit.

(a) Minimum _____
(b) Maximum _____

21. Match

a. Bends _____
b. Supports _____
c. Bushings _____
d. Splices and taps _____

Code section
a. 345-15
b. 345-10
c. 345-14
d. 345-11
e. 345-12

22. What is the standard lengths (as shipped) of intermediate metal conduit.

NAME_____ LESSON NO. A-26

DATE_____ WORKSHEET A-26

ELECTRICAL METALLIC TUBING

1. Electrical metallic tubing is commonly known as: _____

   (a) NECA (b) EMT (c) AWG (d) RHH

2. EMT may be installed exposed or concealed. True/False. _____

3. Number of conductors permitted in metallic tubing is found in Article _____.

   (a) 450-6 (b) 370-6 (c) 346-6 (d) 347-6

4. EMT may be installed at a minimum of _____ inches below cinder fill.

5. EMT may be installed in a cinder fill if it has a _____ inch minimum concrete envelope.

6. Maximum size of EMT permitted is: _____

   (a) 1/4 inch (b) 2 inch (c) 4 inch (d) 6 inch

7. If EMT is installed in wet locations, raintight connectors shall not be used. True/False. _____

8. Concrete tight couplings shall be used on EMT installed in concrete to prevent moisture entering raceway. True/False. _____

9. Bends in EMT shall not exceed _____quarter bends or equivalent _____ degrees between outlets or fittings.

10. EMT shall not be used on electrical systems exceeding _____.

    (a) 600 Volts (c) 120 Volts
    (b) 300 Volts (d) 208 Volts

11. In wet locations, EMT shall be mounted with air space between it and supporting surface at least _____.

    (a) 1/2 inch (b) 1/2 mile (c) 23 meters (d) 1/4 inch

12. The minimum size EMT allowable is:

(a) 1/4 inch (b) 1/8 inch (c) 1/2 inch (d) 1/2 meter

13. Standard length for conduit is 10 ft. but EMT is 5 ft. True/False.

_____

DATE_____ WORKSHEET A-27

RIGID NON-METALLIC CONDUIT AND FLEXIBLE METAL CONDUIT

1. Clips and straps may be used to support flexible metal conduit. True/False. _____

2. Supports from outlets or fittings for flexible metal conduit shall be located a maximum of _____.

   (a) 12 inches (b) 6 inches (c) 3 inches (d) 2 inches

3. Supports for flexible metal conduit shall be located a maximum of _____feet on centers.

4. List three conditions where supports for flexible metal conduit are not required:

   a. _____

   _____

   b. _____

   c. _____

5. Minimum radius bend for flexible metal conduit shall be 5 times conduit diameter. True/False. _____

6. Installation of flexible metal conduit is harder and slower than installation of rigid conduit. True/False. _____

7. Flexible metal conduit must be _____ from outlet to outlet.

8. The minimum size of flexible conduit permitted is _____.

   (a) 1/2 inch (b) 1 inch (c) 3 inches (d) 3/4 inch

9. What is the difference between flexible conduit and liquid tight flexible conduit?

   _____

10. Boxes and fittings for rigid non-metallic conduit is found in Article _____.

    (a) 347 (b) 370 (c) 348 (d) 450

a minimum of _____ inches below grade.

12. Supports of rigid non-metallic conduit is found in Table _____.

13. There are five areas which are not approved for using rigid non-metallic conduit. Which Article covers this? _____?

14. Article _____ covers areas which are approved for using rigid non-metallic conduit.

15. The maximum voltage for rigid non-metallic conduit not encased in concrete is _____ volts. If encased in 2 inches of concrete, can this voltage be exceeded? Yes/No ____. Give the Code Section for your answer. _____

16. Is an equipment grounding conductor always required when nonmetallic conduit is used? Yes/No _____. Give the N. E. Code Article to prove your answer. _____

17. Can field bends and offsets be made in rigid nonmetallic conduit? Yes/No _____. Give the N. E. Code reference to prove your answer. _____

18. Is all rigid nonmetallic conduit suitable for installations above grade and in sunlight? Yes/No _____. Give the N. E. Code Section to prove your answer. _____

NAME_____ LESSON NO. A-28

DATE_____ WORKSHEET A-28

OUTLETS, SWITCH AND JUNCTION BOXES AND FITTINGS

1. Outlet boxes used for interior wiring are classified into the following groups:

   (a) _____ (c) _____

   (b) _____ (d) _____

2. What are the major shapes of outlet boxes?

   (a) _____ (c) _____

   (b) _____ (d) _____

3. Box accessories consist of:

   (a) _____ (c) _____

   (b) _____ (d) _____

4. Can non-metallic boxes be used for metallic conduit systems? Yes/No. _____. Article _____ in the Code Book contains this ruling.

5. List the most important items which determine which type outlet or switch box must be used:

   (a) _____ (c) _____

   (b) _____ (d) _____

6. Can a standard flush receptacle box be used as a floor box? Yes/No. _____. Article _____ in the Code Book contains this ruling.

7. Study carefully the various types of outlet and switch boxes and their accessories as illustrated in the American Electrician's Handbook, and be prepared to discuss them.

8. What determines the length of a straight-thru junction box? Circle the right answer.

   (a) Number of wires.
   (b) Size of conduit.
   (c) Number of conduits.
   (d) Number of joints to be made in the box.

9. How deep and wide must this straight-thru junction box be?

_____

_____.

10. What determines the length of an angle or U-pull junction box? Circle the right answers.

(a) Number of wires.
(b) Size of conduit.
(c) Number of conduits.
(d) Number of joints to be made in the box.

11. Would the answer to question #9 be the same for the angle or U-pull junction box? Yes/No. _____.

12. If a straight-thru junction box is installed in the same conduit run. The straight-thru junction box would be ___. (Circle one)

(a) Longer
(b) Shorter
(c) Same length thru the angle pull junction box.

13. Would the size of the junction boxes in the question above change if the conduit run were paralleled into each of these boxes? Yes/No. _____.

14. Mark the items for each junction box which are changed as a result of paralleling the conduit run.

Straight-Thru	Angle Pull
_____length	_____length
_____width	_____width
_____depth	_____depth
_____stay the same size	_____stay the same size

15. Boxes over 100 cubic inches in size are classified as a _____ or _____ _____ box.

16. Can splice and taps be made in a L.B. conduit body.? Yes/No

NAME _____ LESSON NO. A-29

DATE _____ WORKSHEET A-29

AUXILIARY GUTTERS AND WIREWAYS

1. Wireways and auxiliary gutters are examples, of electrical raceways. True/False. _____.

2. Auxiliary gutters are used to supplement wiring spaces at meter, distribution and switchboard centers. True/False. _____.

3. Wireways are used to house and protect wires and cables. True/False _____.

4. What is the main difference between an auxiliary gutter and a wireway? _____
_____

5. Can auxiliary gutters and wireways be used outdoors? Yes/No. If the answer is "yes," under what conditions may it be used?
_____

6. Can splices and taps be made in auxiliary gutters and wireways? Yes/No. If the answer is "yes," under what conditions may they be made? _____
_____
_____

7. The Code limits the number of current carrying conductors to 30 in both auxiliary gutters and wireways. True/False. _____.

8. Does Note # 8 to Tables 310-16 through 310-19 apply to auxiliary gutters and wireways? Yes/No. Explain.

9. Does a 20% fill capacity limit apply to auxiliary gutters and wireways? Yes/No. _____.

10. If the answer to the above question is "yes," or "no," circle the one to which the 20% fill is applicable.

    (a) Auxiliary Gutter (b) Wireway (c) Both

11. Can aluminum conductors and bus bars be installed in auxiliary gutters? Yes/No. _____.

12. Can aluminum conductors be installed in wireways? Yes/No. _____.

13. Can an auxiliary gutter extend more than 30' beyond the equipment which it supplements? Yes/No. _____.

14. If the answer is "yes," what provisions must be made?
_____.

15. Can conductors be installed before the auxiliary gutter or wireway installation is completely installed? Yes/No. _____.

16. Name six (6) methods by which extensions can be made from a wireway to other items of electrical equipment.

(a) _____ (d) _____

(b) _____ (e) _____

(c) _____ (f) _____

17. Auxiliary gutters may not enclose switches, over-current protective devices or appliances. What Code Section applies to these items? Yes/No. _____.

18. Is an end cap required when a wireway butts against a 4 inch thick concrete wall? Yes/No. _____.

NAME_____ LESSON NO. A-30

DATE_____ WORKSHEET A-30

CABINETS AND CUTOUT BOXES

1. Where in the Code can you find the difference between a cabinet and/or cutout box? _____.

2. The description of a cabinet describes a panelboard enclosure. True/False _____.

3. The description of a cutout box describes an enclosure in which control or metering components may be mounted. True/False _____.

4. Cabinets and cutout boxes can be installed in the following locations. Check the approved ones.

   (a) _____ Hazardous locations
   (b) _____ Outdoors, in the weather
   (c) _____ Subject to "hose-downs" as in a dairy
   (d) _____ In dusty locations
   (e) _____ Indoors, in dry locations

5. Is a cabinet or cutout box of non-conductive material approved by the Code? Yes/No _____.

6. Why are the dimensions for flush mounting in a combustible wall so critical? _____.

7. Only rigid conduit, EMT, and flexible conduit may be run to a cabinet or cutout box. True/False _____.

8. Can unused knockouts be left open in the bottom of a cabinet or cutout box for ventilation? Yes/No. Give the Code section and paragraph rule for your answer. _____.

9. A single 500 MCM conductor per phase is loop fed through one panel with double barrell lugs to another panel. What is the minimum width gutter allowed? _____.

10. How is the gutter width distance measured?

    _____

    _____

11. Can an insulating sleeve be used with a metal bushing on a #4 AWG conduit circuit entering a cabinet or cutout box? Yes/No _____.

12. How many locknuts are required: In question # 11. _____.
Where must it/they be placed? _____.

13. Can a fully insulated bushing be used on #4 AWG conduit circuit entering a cabinet or cutout box? Yes/No _____.

14. How many locknuts are required: In question # 13. _____.
Where must it/they be located? _____
_____.

NAME _____ LESSON NO. A-31

DATE _____ WORKSHEET A-31

STORAGE BATTERIES

1. Match the following letter that corresponds with the number.

   _____ 1. Lead Acid Type Battery a. 1.2. volts per cell

   _____ 2. Alkali Type Battery b. 2.0 volts per cell

2. List two methods of supporting lead-acid batteries:

   a. _____ b. _____

3. List two materials used in construction of racks:

   a. _____ b. _____

4. An electric battery is a device for producing a voltage by: _____

   a. high voltage switch c. chemical means

   b. copper conductors d. dissimilar rubber contacts

5. A battery may consist of a single cell or combination of cells. True/False. _____

6. List two classifications of batteries:

   a. _____ b. _____

7. Secondary batteries may be charged or discharged and are commonly called _____ _____.

8. Primary batteries can be used to discharge only. True/False. _____

9. List three fundamental materials for battery construction:

   a. _____ b. _____

   c. _____

10. The charging rate is expressed in _____.

    (a) amperes (b) volts (c) watts (d) ohms

11. Storage batteries are rated in ampere hours. True/False. _____

12. The maximum temperature of a lead-acid battery should be _____.

    (a) 120° F. (b) 110° F. (c) 50° C. (d) 212° F.

13. Batteries must be charged with direct current and the _____ pole of the charging source must be connected to positive terminal of the battery.

14. Storage batteries require adding _____ only.

15. Study drawing of a primary cell.

16. Study drawing of a dry cell.

NAME _____ LESSON NO. A-32

DATE _____ WORKSHEET A-32

FUSES AND OVERCURRENT PROTECTIVE DEVICES

1. Fuses or overcurrent devices will open circuit to prevent _____ currents from accidentally flowing through equipment and burning it up.

2. When two points in a circuit having low resistance are accidentally connected, it is called a _____.

   (a) short circuit (c) POW

   (b) run (d) sparkling circuit

3. Fuses are rated in _____.

4. A fuse that permits high current in a circuit for approximately 20 to 30 seconds is a _____.

   (a) bad fuse (c) good fuse

   (b) time delay (d) plug in type

5. Fuses are metal resistors with very low resistance. True/False. _____

6. Fuses are connected in parallel with equipment. True/False. _____

7. List three types of fuses:

   (a) _____ (c) _____

   (b) _____

8. Fuses with too low a rating will result in unnecessary _____-_____.

9. What percent overload is a fuse capable of carrying before blowing? _____

   (a) 10% (c) 45%

   (b) 25% (d) 125%

10. Plug fuse will open the circuit in _____ seconds at 200 percent load.

11. Match the following letter to correspond with the matching number:

_____ 1.	Plug Fuse	a. maximum rating 6000 ampere
_____ 2.	Cartridge fuse at 250 volts	b. maximum rating 30 ampere
_____ 3.	Silver sand	c. maximum rating 600 ampere

12. Dual element cartridge fuses contain a thermal element and a fuse link. True/False. _____

13. Plug fuses shall not be rated over _____ volts.

14. The 250 volt cartridge fuse is permitted on _____ voltages.

15. All equipment shall be protected against _____.

16. In residential occupancies all overcurrent protective devices with maximum rating of 20 amperes shall be the time delay type. True/False. _____

17. What percent shall conductors be protected to prevent currents above allowable current carrying capacity of the conductor?

(a) 140% (c) 125%

(b) 110% (d) 100%

18. Temperature will affect the operation of thermally controlled circuit breakers and must be considered in the application and sizing. True/False. _____

19. Plug fuseholders screw shell shall be connected to the _____ side of the circuit.

20. Overcurrent devices shall be installed in each _____ conductor.

21. Overcurrent devices shall be located where conductors receive its supply. True/False. _____

22. Overcurrent devices shall be in _____ _____ locations.

23. Overcurrent devices shall not be _____ to physical damage.

24. Circuit breakers shall be capable of being manually opened or closed. True/False. _____

25. Ampere rating does not have to be visible after installation of breaker. True/False. _____

26. Fuses shall be connected on the _____ side of the disconnect switch.

27. Overcurrent devices is not required on a feeder tap to a panelboard located within _____ feet of feeder.

28. Motor circuit overcurrent protective devices may be rated from _____ percent to _____ percent of motor full-load current.

29. Two types of overcurrent protective devices have been added to the N. E. Code for motor circuit protection. They are:

(a) _____

(b) _____

30. Can fuses be installed in parallel. Yes/No _____.
Give N. E. Code Section. _____

31. Can circuit breakers be installed in parallel. Yes/No _____.
Give N. E. Code Section _____

32. What four items of information are required on each cartridge fuse or circuit breaker?

(a) _____

(b) _____

(c) _____

(d) _____

NAME_____ LESSON NO. A-33

DATE_____ WORKSHEET A-33

LIGHTING FUNDAMENTALS

1. Light may be defined as _____ energy of those wave lengths to which the human eye is sensitive.

2. The color of objects is due to the color of the light that the object reflects or transmits to our eyes. True/False _____.

3. Match the correct word or number with the statement which best describes it:

(a) Visual comfort	____ 1.	The speed of light.
(b) Brightness	____ 2.	Light "out of place" causing eye discomfort or interference with vision.
(c) Glare	____ 3.	The unit of illumination or light density equal to one lumen per square foot.
(d) 186,000 miles second	____ 4.	An expression related to the degree of brilliancy of any surface emitting or reflecting light.
(e) Foot candles	____ 5.	Freedom from direct or reflected glare.
(f) Light bulb	____ 6.	A device for converting electrical energy into visible radiant energy.

4. Rate the three basic light sources as to their efficiency in lumen per watt output: (1st, 2nd, 3rd)

1 2 3 Fluorescent

1 2 3 Incandescent

1 2 3 High Intensity Discharge

5. High intensity discharge lamps can be separated into the following major categories:

(a) _____ (b) _____ (c) _____

6. Discuss the construction of the following types of lamps:

   (a) Incandescent)
   (b) Fluorescent) See illustrations
   (c) High Intensity Discharge)

7. All lamps have similar component parts. List below the five (5) most common parts of a lamp.

   (a) _____ (d) _____

   (b) _____ (e) _____

   (c) _____

8. Rate the three light sources as "Good," "Fair," or "Poor" for the following

	Incandescent	Fluorescent	High Intensity Discharge
Lumen Output			
Lamp Life			
Operating Temperature			
Voltage			
Frequency			
Operation on DC			
Radio Interference			
Ballast Noise			

9. Light output from lamps is measured in _____.

10. The efficiency of a lamp is measured in "lumens per watt" output. True/False _____.

11. Low pressure sodium lamps give a color-balanced light similiar to day light _____ True/False.

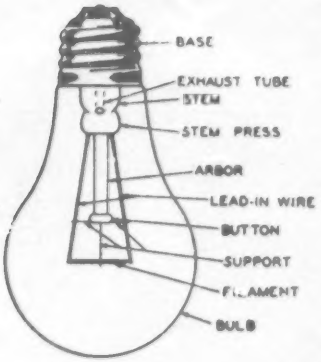
I.E.S. RECOMMENDED FOOT-CANDLE LEVELS*

Art Galleries	
General	30
On paintings (supplemental)	30
On statuary, etc.	100
Social activities	5
Banks	
Lobby general	50
Lobby writing areas	70
Tellers' stations	150
Posting and key punch	150
Churches, Synagogues	
Altar, ark, reredos	100
Choir	30
Pulpit, rostrum (supplemental illumination)	50
Main worship area	15-30
Court Rooms	
Seating area	30
Court activity area	70
Depots, Terminals	
Waiting room	30
Ticket offices	100
Rest rooms and smoking room	30
Baggage checking	50
Concourse	10
Platforms	20
Hospitals	
Corridor	
General	10
Operating and delivery suites and laboratories	20
Lobby	30
Lounge rooms	30
Nurses' station	
General	20
Desk and charts	50
Medical room counter	100
Nurses' workroom	30
Patients' rooms	
General	10
Reading	30
Solariums	20
Waiting room	
General	15
Reading	30

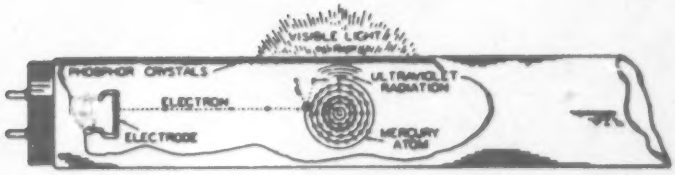
Hotels	
Bathrooms, bedrooms, lobby	
Mirror	30
General	10
Corridors, stairs	20
Entrance foyer	30
Front office	50
Marquee	
Dark surround	30
Bright surround	50
Library	
Reading room	
Study and notes	70
Ordinary reading	30
Stacks	30
Book repair and binding	50
Cataloging	70
Card files	70
Check-in-out desks	70
Offices	
Cartography, designing, detailed drafting	200
Accounting, auditing, tabulating, bookkeeping business machine operator, rough layout drafting	150
Regular office work	100
Reading or transcribing handwriting in ink or medium pencil on good quality paper, filing	70
Reading high contrast or well-printed material, conferring, interviewing, inactive files, washrooms	30
Restaurants, Lunchrooms, Cafeterias	
Cashier	50
Dining areas	
Leisure type:	
Light environment	30
Subdued environment	15
Quick-service type:	
Bright surroundings	100
Normal surroundings	50

*Based on severity of visual task and time available to comprehend details of task. This table lists only a few recommended levels; complete data available from IES Lighting Handbook.

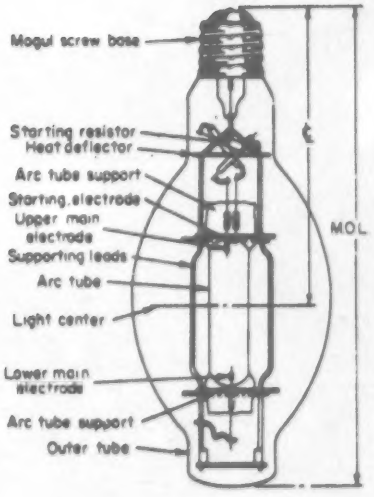
INFORMATION SHEET



INCANDESCENT LAMP



FLUORESCENT LAMP



HIGH-INTENSITY-DISCHARGE LAMP

Electrical Symbols Commonly Used on Blueprints

GENERAL OUTLETS

Ceiling Wall

- Outlet.
- Blanked Outlet.
- Drop Cord.
- Electrical Outlet; for use only when circle used alone might be confused with columns, plumbing symbols, etc.
- Fan Outlet.
- Junction Box.
- Lamp Holder.
- Lamp Holder with Pull Switch.
- Pull Switch.
- Outlet for Vapor Discharge Lamp.
- Exit Light Outlet.
- Clock Outlet. (Specify Voltage.)

CONVENIENCE OUTLETS

- Duplex Convenience Outlet.
- Convenience Outlet other than Duplex. 1=Single, 3=Triplex, etc.
- Weatherproof Convenience Outlet.
- Range Outlet.
- Switch and Convenience Outlet.
- Radio and Convenience Outlet.
- Special Purpose Outlet. (Des. in Spec.)
- Floor Outlet.

SWITCH OUTLETS

- Single Pole Switch.
- Double Pole Switch.
- Three-Way Switch.
- Four-Way Switch.
- Automatic Door Switch.
- Electrolier Switch.
- Key Operated Switch.
- Switch and Pilot Lamp.
- Circuit Breaker.
- Weatherproof Circuit Breaker.
- Momentary Contact Switch.
- Remote Control Switch.
- Weatherproof Switch.
- Fused Switch.
- Weatherproof Fused Switch.

SPECIAL OUTLETS

Any Standard Symbol as given above with the addition of a lower case subscript letter may be used to designate some special variation of Standard Equipment of particular interest in a specific set of Architectural Plans. When used, they must be listed in the Key of Symbols on each drawing and if necessary further described in the specifications.

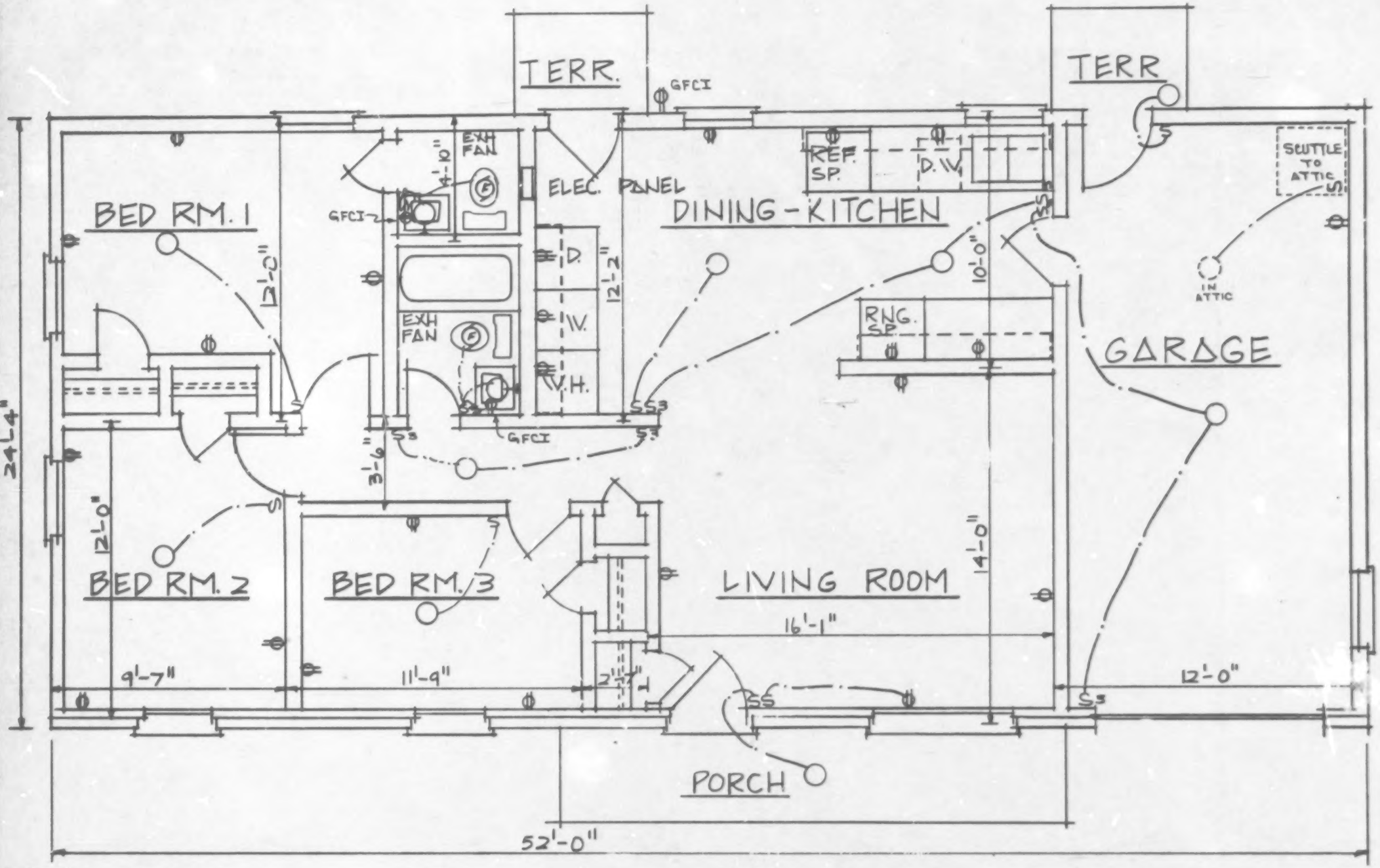
Courtesy of American Standards Association of New York, N.Y.

PANELS, CIRCUITS, AND MISCELLANEOUS

- Lighting Panel.
- Power Panel.
- Branch Circuit; Concealed in Ceiling or Wall.
- Branch Circuit; Concealed in Floor.
- Branch Circuit; Exposed.
- Home Run to Panel Board. Indicate number of Circuits by number of arrows.
  Note: Any circuit without further designation indicates a two-wire circuit. For a greater number of wires indicate as follows (3 wires) (4 wires), etc.
- Feeders. Note: Use heavy lines and designate by number corresponding to listing in Feeder Schedule.
- Underfloor Duct and Junction Box. Triple System. For double or single systems, eliminate 1 or 2 lines. This symbol equally adaptable to auxiliary system layouts.
- Generator.
- Motor.
- Instrument.
- Power Transformer. (Or draw to scale.)
- Controller.
- Isolating Switch.

AUXILIARY SYSTEMS

- Push Button.
- Buzzer.
- Bell.
- Annunciator.
- Outside Telephone.
- Interconnecting Telephone.
- Telephone Switchboard.
- Bell Ringing Transformer.
- Electric Door Opener.
- Fire Alarm Bell.
- Fire Alarm Station.
- City Fire Alarm Station.
- Fire Alarm Central Station.
- Automatic Fire Alarm Device.
- Watchman's Station.
- Watchman's Central Station.
- Horn.
- Nurse's Signal Plug.
- Maid's Signal Plug.
- Radio Outlet.
- Signal Central Station.
- Interconnection Box.
- Battery.
- Auxiliary System Circuits.
  Note: Any line without further designation indicates a 2-Wire System. For a greater number of wires designate with numerals in manner similar to —·—·—12-No. 18W-¾" C., or designate by number corresponding to listing in Schedule.
- Special Auxiliary Outlets. Subscript letters refer to notes on plans or detailed description in specs.



FLOOR PLAN

1978

STUDENT: GARY ROBBINS
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SHEET NO. 1 OF 1.

FLOOR PLAN

GUILFORD TECHNICAL INSTITUTE, JAMESTOWN N.C.

ARCHITECTURAL TECHNOLOGY DEPARTMENT